The Journal of

THE AUSTRALIAN INSTITUTE OF AGRICULTURAL SCIENCE

Registered at the G.P.O., Sydney, for transmission by post as a periodical.

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VOL. 2, No. 4 DECEMBER, 1936.

Experimental Method

The publication in this issue of the fourth instalment of Miss Allan's article on statistical method concludes a series which has served a most useful purpose in bringing before agricultural investigators, in concise form, a survey of the fundaments of this important subject. That these articles have not been within the complete understanding of all readers of this Journal is no reflection on the author's presentation, for it is agreed that some aspects of this science will continue to remain as an enigma to those who have neither a mathematical viewpoint nor the inclination to grapple with the complexities of the subject. It is important, however, that there be no lack in appreciation of the value of the modern, proven and widely accepted methods of experimental technique: the task of planning procedure and analysing results necessarily belongs to those trained and expert in biometrical studies. A fuller realisation of the manner in which the biometrician can assist in the satisfactory conduct of work by

investigators in all other branches of agricultural science, will result in a more scientific approach to experimentation generally.

Dr. John Wishart, the eminent statistician, in a paper read at Cambridge some few years ago, referred to the "suspicion and mistrust of the new methods, resentment at the domination the statistician seemed desirous of exerting over the field experimentalist, and objections raised to the special technique recommended," but added "that where the new methods have been taken up, no attempt that I know of has subsequently been made to go back to older and less accurate methods." The tardy recognition and adoption of sound scientific principles in experimentation in certain sections of Australia is but a repetition of the early experience in England and other countries where to-day there is no semblance of a quibble as to whether the modern methods shall be adopted or not, so convincing have been the results. It is gratifying to note that not only in the leading agricultural research centres of the Commonwealth but also in the technical departments of many commercial institutions interested in agriculture, biometrical methods are now incorporated as a routine procedure in all experimental work.

It should not be necessary here to state that the primary advantage of properly designed experiments is that they allow of the analysis of results to determine whether observed differences are to be regarded as true (significant) differences, or not. Without this knowledge years and years of accurate and detailed experimental work can be, and often have been, absolutely wasted. The point which now emerges is that it is very frequently just as convenient to conduct an experiment on modern lines as by the old methods. Professor Fisher's original Randomised Block and Latin Square designs are in consequence accepted and applied—with a few invidious exceptions—throughout the world. What is needed for the future is a more general appreciation of the added advantages often to be gained by adoption of the more advanced and statistically more technical methods—such as factorial design in the planning of experiments, or covariance and regression in analysis—which have been developed by Fisher, Yates, Wishart, Snedecor and others. There is need, also, for more general acquaintance with such features as the improvements now available in sampling technique and the saving in labour often possible by proper planning, whilst still maintaining the desired standard of accuracy in an experiment.

Modern methods of experimentation are by no means applicable only to field work in agriculture. The voluminous technical literature of recent years bears striking testimony to the wide range of application of the subject, extending as it does into all branches of scientific research. And the importance attached to advances in statistical theory and their possible implications in relation to experimental work generally, may be gauged by the publication since 1934 of the Supplement to the Journal of the Royal Statistical Society, devoted solely to these aspects of the subject.

The Profession of Research in Science

By

G. A. Currie, D.Sc., B.Sc.Agr.

Scientific research is recognised in this day and generation as an essential part of the organisation of all highly civilised communities. Research has become a profession, but unlike those engaged in many other professions the research worker is not paid directly by the community for the benefits it receives from his efforts. He has a fixed salary and has less autonomy than many other professional men. The conditions under which he works are largely created for him yet his work is independent and constructive to an unusual degree. The purpose of this article is to attempt to analyse the conditions under which he may be expected to do his best work, and so to render most service to the community which supports him, and to the world at large. We are not concerning ourselves here with research workers in private industries—their salaries and working conditions are controlled by the organisation which employs them—but with those employed by Government Departments and Institutions, or any other organisation endowed by private and/or public money.

In order to analyse the position, it is necessary to consider the personnel engaged in research, the atmosphere in which the best work may be carried out, and finally, the standard of pay which the scientist may reasonably expect from the community for his work.

The Research Worker:— Nowadays the worker is usually a fairly normal, well trained individual who has taken up the work as a profession, though one still finds (and let us hope will continue to find!) an occasional colourful but eccentric being working in the laboratory. The modern scientist may not be fired by the consuming passion for research which the public attributes to scientists of another day, but he must have a spark of the passion in him or he would not choose research as his life's work. In order to have chosen this profession he must have an enquiring mind and some love of knowledge. To be successful in his work he needs to be well-trained, observant and methodical. Above all, however, he must have a keen analytical mind, inventiveness, and the faculty for constructive reasoning, all of which can be included in the description "having a flair for research."

Concentrated on his work, as he must be, and frequently somewhat introspective by nature, he is apt to become narrow in outlook, sensitive, jealous of what he considers proper recognition for his work, and prone to envy.

Atmosphere for Research:— It is almost a truism that most normal individuals will do their best scientific work when they are free from any major conflict and when their work is carried out in a calm atmosphere in which they can give the whole of their minds to the problem in hand. A well equipped laboratory and freedom from noise and bustle in it are very important but it is more with the mental atmosphere that we are concerned. (Freedom from financial worry is important, but the scientist has rather moderate demands on money and a later section will be devoted to the salary level which will generally allow him to do his best work.)

Some responsibility for creating a favourable atmosphere lies with the individual scientist who must be keen and sufficiently unselfish to work amicably with his colleagues, especially if he is a member of a team working on a special problem. His first care must be his work, however, and to it he must direct his faculties. In the pursuit of results he has to guard against hasty and shoddy work, quality must mark his labours. At the same time he must not stray into paths of intriguing scientific interest which do not lead even indirectly to the desired end. He can contribute to the healthy atmosphere of the laboratory by a cheerful irreverence for the scientific opinions of his colleagues. This is an excellent antidote to ponderous dignity on the one hand and over-sensitiveness on the other.

The greater responsibility for a good atmosphere in the laboratory rests, however, with the senior men. It is for them to see that individual workers get the equipment essential for their work, freedom to work without irritating interruption, sympathetic constructive criticism when it is required and such minimum amount of practical direction as may be desirable. Discipline should only be an expression from within of colleagues working to a common end; any form of discipline which is based only on power and imposed as petty tyranny is inimical to good research. All workers, senior or junior, have an equal dignity which must be mutually respected if a harmoniously working organisation is to be maintained. Criticism to be healthy must be mutual as well as constructive. The use of the whip is almost always calamatous, the spur—and in some instances some spur is desirable—should be inspirational to be effective.

The qualities which make a brilliant research worker do not qualify him for administrative responsibility unless they are combined with other personal attributes. A mind quick to grasp essentials, a true appreciation of scientific methods, a sound practical outlook backed by experience, a wide tolerance and human understanding, and the capacity to translate thought into effective action all help in the senior man to produce a sound and vigorous organisation. He should be marked by a broad and strong mind rather than a narrow and deep.

In order that a staff may be unified to produce that super-organism which is an "emergent" from the sum of its scientific workers some integrating forces

must operate. It is necessary that all individual workers should have free access to a director or one of his deputies with whom work may be discussed fully and sympathetically and staff problems resolved. Some means should be found for bringing the staff together from time to time to discuss problems or scientific news; isolation of a worker on his problem may be a good thing for a time, but usually he finds it an advantage to meet his colleagues occasionally; a tuning-up of faculties seldom fails to result from stimulating discussion. The quality of such discussion is the responsibility of all members, but the tone can be influenced most by the contribution of those in authority. For best results in our laboratories as they are at present constituted, each worker should be given all possible credit for his work and should be allowed to publish it under his own name unless there is good reason for not doing so. Reputation is to the scientific worker what a bank balance is to the business man.

It may be profitable to consider for a moment an institution which is recognised as having an ideal atmosphere for research and which is producing work of a high value. This is Rutgers College, New Jersey, U.S.A. Commenting on the College, in the course of an appreciation of the Director, Dr. Jacob G. Lipman, Sir John Russell said: "One finds at the station a peaceful atmosphere conducive to scientific thought and quiet reflection, perhaps the most important factor in promoting research work." In addition to his ability in research which has gained him an international reputation as a leading scientist, some of the other qualities of the Director which have produced this atmosphere are recorded by commentators as follows:—

"A sense of humour. Evenness and continuity of temperament and patience. Willingness to delegate authority. A good judgment of men. Willingness to go to the very end of a line of thought or action (with a member of staff) to clarify it. Openness of mind and honesty."

*Salary**:— The salary paid to the research worker from public funds should be at least as high as the value the community places on research work, and this is in part a reflection of the value of the work to the community. Let us consider some of the methods which might be used to determine the rate of pay of the research worker.

(1) *Payment by Results*:— So complex are the problems on which the scientist works that it is frequently impossible to give a money value to the results of reasearch. In pure research the results are frequently of cultural

*An excellent analysis of the general position concerning salaries of professional workers in Govt. service can be found in "Proceedings Before the Commonwealth Public Service Arbitrator." Determination No. 3 of 1936, pp. 5-15.

value only at the time they are obtained, but in a few decades discoveries of fundamental principles may change the face of the earth. Payment by results is an impossible criterion to apply to community-supported research organisations. It is too much like receiving tips to commend it to professional scientists, and takes no account of the relative difficulties in the problems allotted to them.

(2) *Payment by experience and mental attributes*: Experience may teach some men little, others much.

There is no doubt that the ingenuity, tenacity of purpose and capacity for deductive and inductive reasoning, as well as other qualities of mind are different for every individual, so that if total capacity is to be taken as a criterion on which to base remuneration, every worker would have to be paid at a different rate. No authority is capable of estimating the total effective mental attributes of different scientists, so although big differences in intellectual equipment and character may be used to some extent to assess difference in values, this cannot be the sole criterion on which remuneration should be judged.

(3) *Payment by Responsibility*: This is used in all institutions for assessing values of the personnel. In the scientific institution it has a place, as it has elsewhere, but again it should not be used as the sole criterion. There is a great danger that a man who has shown himself to be a good research worker may be rewarded by being placed in an administrative position for which he had neither the training nor the qualities of character necessary for success. In a research organisation some means should be found to reward research workers for good work without taking them away from that work into some position for which they are not fitted. A scientist who is capable of, and called upon to carry out research work of such a high order that only a few others in the world could perform it should be paid at any special level, even greater if need be than the most highly paid administrative post in the organisation. Instances such as this would be very rare in practice. Extra responsibility, when it has a meaning in any real sense implying that the post demands attributes in addition to those needed for research work proper, should reasonably be paid at some rate higher than that paid to individual research workers.

(4) *Payment at a level acceptable to the Community*: This somewhat nebulous heading contains the essential concept in fixing the general level of salaries in organisations supported by public funds. For the purpose of salary determination for scientists the community is represented by commissioners, boards, and high officials generally, and their judgment is based on: (1) what they have to pay to get men adequately trained and of a high enough quality of intellect, (2) what the community will not cavil at. In Australia at the present time the community itself is suggesting better salaries for scientists and certainly no complaint is heard about scientists being overpaid.

It is suggested that the criteria on which salaries may be assessed are as follows:—

(1) The scientist of some years' standing is likely to be contented on a salary which is a reflection of the opinion of the community of the value of his work. The status would probably be that of a middle class professional man in business or in other service. A guess at this level for Australia today is £400 rising to £700 per annum for individual workers whose responsibility is limited to their own researches. The lower figure is for an established scientist at about 25 to 30 years of age, the latter for a scientist of about 45 years of age. The research worker one has in mind is the man who is highly trained, has higher than average ability, some experience, and proved capacity for research work. He must also be called upon to undertake work in which individual initiative is essential. Workers called upon to do routine scientific work to a set programme only, would not be classified as research workers but rather as technical officers. This article does not deal with technical officers who would necessarily have a classification lower than the research worker, nor does it deal with senior officers whose responsibilities and qualities may entitle them to a higher classification.

(2) Increments between these extremes could be larger at first and smaller later, to run parallel to the usual rate of increase of financial responsibility and reflect the value of added experience. To provide a contented and consequently efficient organisation, increments should be continuous. Automatic increments should be able to be stopped if necessary by a definitely adverse report from the officer in charge.

(3) All workers doing work of a comparable nature should be on the same range of salary, and for a stable organisation that range should be an extensive one.

(4) Some mechanism should exist whereby individual workers of outstanding merit called upon to do highly creative work should be able to receive remuneration at any rate which the special circumstances warrant.

(5) Responsibility, when it demands extra qualities to sustain it, should be given such higher remuneration as circumstances may determine.

The ordinary competition between organisations should serve to give that outlet which some forceful individuals need for their special energies. At the same time the principles named should serve to keep staffs sufficiently stable to do long continued work and yet give sufficient freedom of movement to avoid any stagnation.

To summarise: (1) The scientist works best in a calm atmosphere in which he is given the greatest possible amount of freedom to pursue his researches in his own way. He is keener on his work for its own sake rather than for the sake of big monetary reward, so every credit should be given him for his work.

(2) Difficulties in the laboratory (apart from financial) are generally personal, so those in administrative positions should not be chosen for their ability in research only, but also for personal qualities such as leadership, inspiration and integrity.

(3) Especially brilliant individual research workers should be able to receive a status and salary equal to those given for the higher administrative posts. Pride in research work may thus be encouraged, not pushful competition for place.

(4) Wide differences in remuneration between individual research workers responsible for their own problem only, should be avoided. For best work, a salary permitting the average scientist to live at the level of a middle class professional man should be assured.

The Investigation of Orchard Fertilizer Requirements

By

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Horticultural research is rapidly becoming a more important phase of the work of Departments of Agriculture throughout Australia, and the problems under investigation or in need of investigation are many and varied. It would be difficult, and perhaps ill-advised, to attempt a classification of horticultural problems according to their relative importance, but those who are in close contact with the fruit growing industry know how consistently growers demand more precise recommendations in regard to fertilizer application. They also realize how frequently it is necessary for horticultural extension officers to tender approximate advice, and will agree that fertilizer requirement of fruit trees and vines is a subject demanding vigorous and detailed investigation.

Until recent years, research into fruit tree manurial problems was virtually confined to the conduct of non-replicated field trials—experiments which have been aptly described by Chandler as "having not yielded as valuable results as was expected of them." When one considers the difficulty of horticultural material from a field experimental standpoint—the permanent nature of the crop, the relatively small number of plants per unit area (as few as 50-70 per acre), and the inherent variability in size, vigour, and productivity of individual trees,—it is not surprising that early field experiments produced such meagre results.

During the past decade, considerable advances have been made, not only in regard to the design and technique of horticultural field experiments, but

also in respect to other lines of approach to problems of fruit tree nutrition, and the research worker now has several effective implements with which to study fertilizer requirements.

General principles concerned in the planning of controlled field experiments have been clearly stated by various eminent biometricians, but the application of these principles to the design of horticultural experiments has necessitated intensive study of the order and nature of the variability exhibited by various horticultural crops. Uniformity trials have been conducted by many workers on a wide range of fruit crops, and on the basis of such trials it has been possible to lay down fundamental requirements in respect to horticultural field trials. Field fertilizer trials may now be designed in such a way as to enable them to answer positively all those questions which it is reasonable to expect may be answered through the medium of plot trials. Whereas the results of past field experiments have been inconclusive, and often conflicting, we may now look forward to more clear cut and more reliable results of field experimental work.

Concurrently with the gradual establishment of the principles of sound plot technique, there has occurred a rationalism of outlook on problems of fruit tree nutrition; more attention has been given to the inter-relations between tree growth and cropping, to the importance of maintaining general tree health and to the more subtle reactions of trees to various mineral deficiencies.

Today the orthodox field experiment is only one of the implements which the research worker may employ in his efforts to determine fertilizer requirements of fruit trees.

The practical value of plot culture experiments as conducted by Wallace in England and subsequently by Read in Victoria in establishing mineral deficiency symptoms of various types of fruit trees is considerable; in Victoria, the symptoms exhibited by apple trees when grown in sand cultures under deficiencies of nitrogen, phosphorus, potassium, calcium, and magnesium have been demonstrated and recorded. These established deficiency symptoms concern such features as relative times of bud-burst and defoliation, type, character and amount of growth, size and colour of leaves, manner of defoliation, character of Autumn tints etc., and their value in assisting the interpretation of results of field trials and for general diagnostic purposes in commercial orchards is obvious. Further pot culture work is projected in Victoria—this time to establish mineral deficiency symptoms for pears—and it is undoubted that well advised extension of pot culture studies to embrace other types of fruit trees, vines and bushes, will substantially assist towards the solution of many fertilizer problems.

Another method of attack on fruit tree manurial problems is that of injection direct into the tree of mineral solutions. A simple technique has been evolved by Roach, whereby a whole tree may be injected with a single solution,

or each main limb, with its own roots, injected independently with a different solution. The advantages of direct tree injection of fertilizers are patent: there is certainty that the fertilizing substance has been taken up by the tree or limb, and moreover, different treatments may be applied to reasonably comparable branches on a single horticultural unit—one tree.

Although the technique of actual injection is satisfactory, there still remains some doubt as to the dosages of particular materials which may be safely administered to various types of trees. However, the problem of safe dosage is not an insuperable one, and tree injection must be regarded as having great possibilities as an additional means of diagnosing mineral deficiencies in the orchard. Furthermore, in view of the simplicity of the operation, it it quite possible that tree injection may have future practical value in the treatment of established deficiencies in commercial orchards—especially as a means of supplying minerals which are slow acting, or which undergo transformation when incorporated with the soil.

Soil analysis has been long regarded as only of supplementary value in the diagnosis of mineral deficiencies, and in the investigation of fertilizer requirements; the recent activity of soil workers in connection with the evolution of simpler and more rapid chemical tests for interpreting the nutrient supplying power of the soil has, however, aroused new interest in the more general application of soil analysis to field problems. Admittedly, different plants, and even fruit trees of the same variety on differing rootstocks show variation in their ability to extract nutrients from comparable soils, but should satisfactory rapid tests for available nutrients become standardised (and considerable advance has been made in this field), such tests may ultimately play a more important part in fertilizer investigational work.

The foregoing does not purport to set out all modes of attack on orchard fertilizer problems; it does, however, indicate how much better equipped we are today in respect to the investigation of such problems, and that we may undertake the task of determining fertilizer requirements with greater confidence of obtaining reliable data.

Supplementary Hand-feeding of Merino Sheep in Western Australia

The following is a report of a paper presented by Dr. E. J. Underwood, and discussed by members, at the General Meeting of the Western Australian Branch of the Institute on October 9, 1936.—Ed.

Work carried out by Dr. E. J. Underwood and Mr. F. L. Shier in the Department of Agriculture in connection with investigations of Toxic Paralysis of sheep, has thrown light on the question of the need and value of hand-feeding of Merino sheep during the dry summer period. The results of this work, as far as it has gone, were outlined by Dr. Underwood at a recent meeting of the Western Australian Branch of the A.I.A.S.

It was pointed out that the salient feature of the Western Australian wheat belt was its long, hot, dry summer, in which no pasture growth took place, thus imposing a period of poor nutritive conditions on the growing sheep. Associated with this position was the fact, which was not so well realised, that the disability was accentuated because the so-called pastures of the wheat belt were exceedingly poor, and their development had been very seriously neglected by farmers. In view of the fact that it was impossible to get pasture herbage to grow during the dry summer, it was suggested that the good period of the year should be used to provide for the poor season by the conservation of fodders and grain for feeding sheep in the summer.

Work carried out during the past four years on this question was largely devoted to measuring the effect of various supplementary feeding treatments during the summer period on growth and wool yield of sheep. These experiments were carried out at the Research Stations at Meckering and Beverley. It was shown that phosphatic licks had no effect on the growth of young sheep, or in sustaining the live weight of mature sheep during the summer. Feeding on concentrates, such as wheat, oats or linseed meat-meal, produced a significant increase in the growth of sheep during the summer as compared with the control sheep which were on dry grazing alone. During the subsequent green feed period, however, the control sheep overtook the hand-fed sheep and reached the same ultimate live weight by the month of December.

Wool yields were obtained from the sheep used in these experiments, and it was demonstrated that the use of phosphatic licks had no effect. The supplementary feeding, however, produced variable increases in wool yield from a fraction of a pound to as much as $1\frac{3}{4}$-lb. per sheep for the year. In no case was the value of this increase in any way sufficient to pay for the cost of the feeding stuffs used. The increases in wool yield due to the feeding of small

protein concentrates, such as meatmeal and bloodmeal, were not comparable to those obtained in Queensland in the Meteor Downs Experiments carried out by the Council for Scientific and Industrial Research. A large response from the use of such materials could not be expected in the wheat belt of Western Australia.

Consideration of the growth and weight curves of Merino sheep in the wheat belt of Western Australia shows that a falling-off in weight and condition is usual during the late summer and autumn periods when only dry grazing is available. This experimental work indicates that this loss in weight is not harmful to sheep, provided it is maintained in a healthy, thrifty condition. Under these conditions, too, a most profitable wool yield is obtained as the wool produced is sound and the extra wool grown under supplementary hand-feeding is not sufficient to compensate for the cost of hand-feeding.

It was suggested that farmers should adopt an attitude of caution in arranging their programme of supplementary hand-feeding during the late summer and autumn periods as it would be economical judiciously to allow the Merino sheep to fall away in condition and lose weight on a submaintenance grazing ration. Apparently the Merino sheep suffers no ill-effect from this treatment and economic advantage can be taken of this capacity.

During the discussion which followed Dr. Underwood's address, it was emphasised that to maintain the sheep in a thrifty condition when the feed is inadequate in quality or quantity, supplementary hand-feeding is frequently necessary. Under these circumstances it is undoubtedly economical as it avoids losses and enables the farmer running ordinary flock sheep for wool production to make maximum use of the natural grazing when the pastures are at their best.

L.J.H.T.

Disease Resistance in Plants*

By

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Plant pathologists are concerned not only with an exceedingly wide range of hosts which differ very fundamentally from the animal organism, but also with the fact that environmental factors have such an important bearing on infection phenomena and the subsequent development of disease symptoms. Such aspects as the thickness of the cell wall and its various modifications, the presence of hairs, waxy coverings, development of woody tissues and of cork, stomatal behaviour and so on may determine the ease with which infection occurs or the extent of disease development.

*Summary of an address to the Pathological Society of New South Wales, Medical School, University of Sydney, on 20th October, 1936.

Many factors, however, are involved in the infection process. Contact tropisms are important in the "fungous infection peg" type of penetration of the cell wall but infection, susceptibility or resistance cannot readily be explained on a basis of positive or negative chemotropism.

Symbiotic relationships are recognised in the bacterial nodule formations of leguminous plants, the mycorrhiza of orchids and of many trees. The mutualistic balance is delicate and may be upset by changes in an environmental factor. A pathogen and host relationship also may be established in which there is no obvious sign of disease development for relatively long periods, as in the case of bunt or loose smut of wheat or the black-spot disease of citrus. This aspect of tolerance is in marked contrast to the hypersensitive reaction of a wheat variety resistant to a particular strain of the stem rust fungus.

The compatability or incompatability of host and pathogen obviously depends on the physiological relationship, but exceedingly little is as yet known as to the actual nature of the reactions involved. Varietal resistance to onion smudge is correlated with the presence of a substance associated with the coloured scales of the onion; tissues unprotected by such scales, however, may become infected. The resistant qualities of host plants generally, have not been correlated with the existence of chemical entities which may be isolated from the cell contents.

European workers, in particular, have studied possibilities of inducing resistance by a "vaccination" process in which seeds or plants are treated with products derived from culture of pathogens in artificial media. In some cases, a temporary change in the physiological condition of the host appears to have been effected, but the work as a whole is as yet incomplete and somewhat contradictory. Under field conditions, it is well known that immunity is not conferred on the plant after recovery from an initial infection. Generally speaking, plants are subject time and time again, to subsequent infections.

Some interesting aspects on the relation of fertilisers to resistance have recently been indicated by Professor W. Brown. Nitrogenous fertilisers favour a softer and more succulent type of development in the host, but the nature of the substratum influences also the type and quantity of enzyme production by the pathogen. Destruction of tissues is favoured, *inter alia*, by an increased nitrogen content of the plant cell which results in increased development by the pathogen of the enzyme responsible for solution of the pectic substances of the middle layer of the cell wall.

Virus disease relationships present many interesting features, and it is conceivable that a knowledge of the actual nature of the virus will lead not only to an explanation of phenomena associated with resistance and susceptibility to virus infections, but may have a bearing also on the nature of plasmic resistance to fungous and bacterial infections.

Some Principles of Statistics and their Application to Agricultural Experiments. IV.

By
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GOODNESS OF FIT TESTS.

Essentially any of the significance tests used in modern statistics could be regarded as a test of the goodness of fit of a set of observations to some particular hypothesis. In a simple fertilizer trial, for example, the data are compared with a homogeneous population in which there is no difference between the treatments. But the term " goodness of fit " was given a specialized meaning by Professor K. Pearson when he introduced the method now known as the " Chi-squared test of goodness of fit " for comparing observed with expected frequencies. This still remains the best general criterion for comparing frequencies, though certain modifications have been found to be necessary. Its use was extended to testing the fitness of regression formulæ, but Professor Fisher has shown that the best way to test the goodness of fit of regression lines is by the analysis of variance. It is the purpose of this paper to illustrate the use of the analysis of variance in testing the fit of regression formulæ, and the application of the χ^2 test to various types of problems involving different hypothetical distributions.

THE FIT OF A REGRESSION LINE.

The goodness of fit of a regression line is to be distinguished from the significance of a regression coefficient, which can be found by Student's t-test. The goodness of fit can only be tested when the observations are classed according to values of the independent variable. There will then be a number of different values of y corresponding to each value of x. Such a set of values is called an array. For example, suppose observations have been made on the date of earing and subsequent yield of wheat plants. We might class these observations according to their dates of earing. The yields corresponding to a particular date of earing would then constitute an array.

Suppose x_p represents any class value of x, and that n_p is the number of observations in that class. We could find the mean value of y in each array. Let these means be $\bar{y}_1, \bar{y}_2, \ldots \bar{y}_n$. The sum of the squares of deviations of

the values of y from their general mean can be divided up into two parts, namely, the sum of squares of deviations of each value of y from the mean of its own array, plus the sum of squares, weighted according to the frequency in an array, of deviations of the array means from the general mean. In symbols, this is expressed by the identity

$$S(y-\bar{y})^2 \equiv SS(y-\bar{y}_p)^2 + S\{n_p(\bar{y}_p-y)^2\}$$

The last term in this expression can be further divided into a part measuring deviations of array means from the regression line plus a part representing the effect of the regression line. The identity is then written

$$S(y-\bar{y})^2 \equiv SS(y-\bar{y}_p)^2 + S\{n_p(\bar{y}_p-Y_p)^2\} + b^2S(x-\bar{x})^2$$

where b is the regression of y on x, found in the ordinary way, and Y_p is the value of y found from the regression line when the value of x is x_p. The first two terms of the right hand side taken together will give the sum of squares $S(y-Y)^2$ which is used in testing the significance of b.

By dividing each of the terms on the right hand side by its appropriate number of degrees of freedom, three estimates of variance are obtained. They are the within-array variance, the variance due to the deviations of array means from the regression line, and the variance due to the regression line itself. A comparison of the second with the first shows whether the array means deviate from the regression line by an amount greater than can be accounted for by the random variation within the arrays.

There might be considerable variation of the values of y in each array, and yet the mean values of y for different values of x could lie very closely on a straight line. The significance or otherwise of the slope of the regression line does not necessarily imply a good or bad fit of the means to a straight line.

The following example illustrates the process. The data are taken from a uniformity trial, and represent the yields from 150 pairs of adjacent plots. The independent variable is the yield of the left hand plot of the pair, and y is the yield of the right hand plot. To simplify the working, the unit of yield has been chosen so that the values range from 1 to 13. Does a linear law satisfactorily represent the relationship between the variables?

A double frequency table such as this is called a correlation table. The class values of y together with the total frequency column on the extreme right of the table form the general frequency distribution for y, and $S(y-\bar{y})^2$ can be found in the usual way from it. In the same way $S(x-\bar{x})^2$ could be found from the bottom row of frequencies. The other quantity that is needed in finding the regression coefficient is $S(xy) - \dfrac{S(x)\ S(y)}{n}$. To find $S(xy)$ from a correlation table we must multiply every product of values of x and y by the frequency with which that pair of values occurs, and sum the results. For example, the values of $x=5$, $y=6$ occur twice, and these pairs would therefore contribute $2\times5\times6$ to the total sum, $S(xy)$. The total value of y in each

FREQUENCY TABLE OF PAIRS OF OBSERVATIONS.

y	x												Total.
	1	2	3	4	5	6	7	8	9	10	11	12	
1		1			1								2
2		3	2										5
3		4	1	2	1	1		2					11
4	1	2	1	1	1		1	1	1				9
5	1	1	1	2			1						6
6			3	4	2	2	2		1	1		1	16
7	1		1	2	3	3	2	1	3		1	1	18
8	2		2	2	1	3	3	4	2	3	1		23
9			1		2	4	3	5	3	2	2		22
10	1				2	2	3	2	3	3	3		19
11					2	3	1			1	1	2	10
12							1	1	2	1	1	2	8
13												1	1
Total	6	11	12	13	15	18	17	16	15	11	9	7	150

array is found by multiplying each class value by the frequency with which it appears. These totals are 42, 32, 66, 74, 109, 149, 139, 126, 128, 101, 86, 72. The values of $y_1, y_2 \ldots y_{12}$ could be found by dividing by the corresponding total frequencies.

The quantity $S\{n_p(\bar{y}_p - \bar{y})^2\}$ is best found from $S\left\{\frac{(\text{array total})^2}{n_p}\right\} - \frac{(\text{total for } y)^2}{n}$, these two formulæ being identical. In this example,

$$S(x - \bar{x})^2 = 1333 \cdot 49$$
$$S(y - \bar{y})^2 = 1135 \cdot 49$$
$$S(xy) - \frac{S(x)\ S(y)}{n} = 693 \cdot 49$$
$$S\{n_p(y_p - \bar{y})^2\} = 485 \cdot 04.$$

In carrying out the analysis of variance for testing the goodness of fit of

the regression line, it is not necessary to calculate the separate values Y_p, because the term $S\{n_p(\bar{y}_p - Y_p)^2\}$ can be found by subtracting the other two terms on the right hand side of the identity from $S(y - \bar{y})^2$. The term $b^2S(x - x)^2$ is equal to $\dfrac{\left\{S(xy) - \dfrac{S(x)S(y)}{n}\right\}^2}{S(x - x)^2}$ and this is found to be 360·66.

We then have the steps:

$$SS(y - \bar{y}_p)^2 = S(y - \bar{y})^2 - S\{n_p(\bar{y}_p - \bar{y})^2\} = 650{\cdot}45$$

$$S\{n_p(\bar{y}_p - Y_p)^2\} = S(y - \bar{y})^2 - SS(y - \bar{y}_p)^2 - b^2S(x - \bar{x})^2 = 124{\cdot}38.$$

There are 149 degrees of freedom, that is, one less than the total of 150, corresponding to the total sum of squares. There are 12 array means, and therefore 11 degrees of freedom for the sum of squares between arrays. This leaves 138 degrees of freedom for the within-array term. The 11 between arrays can be divided into 1 for the regression line, since the regression is of the first degree only, and 10 for deviations of array means from the regression line. This gives the following result.

ANALYSIS OF VARIANCE.

Source of Variation.	Degrees of Freedom.	Sum of Squares.	Mean Square.
Between arrays — Regression	1	360·66	360·7
Between arrays — Deviations from regression	10	124·38	12·4
Within arrays	138	650·45	4·7
Total	149	1135·49	

The ratio $\dfrac{\text{mean square of deviations}}{\text{mean square within arrays}}$ is 2·6. This value is significant, showing that a straight line does not satisfactorily represent the relation between mean values of y for given values of x.

If the array means are plotted against the values of x, it can be seen where the discrepancy lies. It may be due to some competition effect.

THE CHI-SQUARED TEST.

In a number of biological problems, the main interest is the frequency with which the observations fall into certain classes. For example, the plant breeder will class the plants resulting from a cross, according to particular

characters ; he will count the number that fall into each class, and will then want to compare these frequencies with those to be expected according to genetical theory. The research worker who is studying the incidence of some disease in plants or animals, will also be concerned with frequencies. It may be suspected that the deaths in a flock are associated with a particular disease. If the numbers of infected and uninfected animals were counted, both in the living flock, and among those that had died, a comparison of the numbers obtained would show whether there had been an undue proportion of the disease among the dead animals. If there had been, this would indicate an association between the disease and death. If, however, the proportion of disease was approximately the same in the two groups, there would be no reason to assume any such association. The χ^2 test is the appropriate one to use in all such cases. It was developed for comparing observed with hypothetical frequencies, but its use has been extended to include comparisons of the second type.

If $x_1, x_2, \ldots x_n$ are the frequencies with which a set of observations fall into n specified classes, and if $m_1, m_2, \ldots m_n$ are the frequencies expected according to the given hypothesis, then

$$\chi^2 = S\frac{(x-m)^2}{m}.$$

Pearson, in 1900, showed that, subject to certain assumptions, the probability of getting χ^2 greater than any particular value by random chance could be determined mathematically. This probability depended on the number of terms in the sum making up χ^2, and Elderton prepared tables of the probabilities corresponding to given values of χ^2 and n. It has since been shown by Fisher that it is the number of independent quantities $(x - m)$, that is of importance rather than n itself. This figure is called the number of degrees of freedom. If the data have to be used to estimate the expected frequencies, the number of degrees of freedom will be reduced according to the formula employed in the estimation. Some examples will be given subsequently to illustrate the rules for this reduction. If Elderton's table is used, allowance must be made for this reduction in the degrees of freedom. Fisher gives a table for χ^2 in " Statistical Methods for Research Workers ", entered with n equal to the number of degrees of freedom, and this is to be used without adjustment. In order that the assumptions made in deducing the χ^2 distribution shall be valid, it is necessary that none of the expected frequencies should be very small. A limit of 5 is generally taken, though even this is rather low. When the expected number in any class is less than this, two or more classes must be grouped together.

Recently Yates has shown that the test can be made more accurate by modifying the formula for χ^2. Instead of using deviations such as $(x - m)$, reduce the numerical value of each such quantity by one-half before squaring.

Use the same χ^2 table, and the same rules for degrees of freedom. This correction is needed because the theoretical χ^2, whose distribution is used to determine the probabilities, varies continuously, while the quantities with which we are concerned are discontinuous. The modification is known as the correction for continuity.

Example 1.

In an experiment described in the Second Report of the Evolution Committee of the Royal Society, 1905, the following results are quoted from a certain cross: 5321 plants gave yellow seeds and 1804 gave green seeds. Are these figures in agreement with Mendelian expectation of a proportion of 3 yellow seeds to 1 green?

This data illustrates the simplest type of frequency distribution—a simple division of the observations into two classes. We have:

OBSERVED DISTRIBUTION.

Yellow Seeds.	Green Seeds.	Total.
5321	1804	7125

According to the hypothesis we wish to test, 7125 observations would be expected to be divided in the following way:

EXPECTED DISTRIBUTION.

Yellow Seeds.	Green Seeds.	Total.
5343·75	1781·25	7125

We find

$$\chi^2=\frac{(5321-5343\cdot75+\frac{1}{2})^2}{5343\cdot75}+\frac{(1804-1781\cdot25-\frac{1}{2})^2}{1781\cdot25}=0\cdot37.$$

There are two quantities contributing to χ^2, but since the totals have been made to agree in the observed and hypothetical distributions, only one of these could be chosen arbitrarily; the other being determined when it has been chosen. Consequently there is 1 degree of freedom. The general rule in problems of this kind, where the proportions expected in the classes are known beforehand, is to subtract one from the number of classes. Had there been four classes, with the expected ratios of 9 : 3 : 3 : 1, there would have been 3 degrees of freedom.

The χ^2 table shows that the probability of exceeding the value 0·37, by chance, is a little greater than 0·5. This result therefore might well have arisen by chance alone. A probability of 0·05 or less is generally taken as indicating a significant departure from expectation.

Example 2.

In an experiment for testing the efficacy of traps in controlling the amount of blowfly strike in sheep, the following results were obtained:

NUMBER OF STRIKES OBSERVED.

Trapped Area.	Untrapped Area.	Total.
31	96	127

Does this demonstrate a real difference between the two areas? If there were no difference, we should expect equal numbers of strikes in the two areas. Thus we should have:

NUMBER OF STRIKES EXPECTED.

Trapped Area.	Untrapped Area.	Total.
63·5	63·5	127

Then

$$\chi^2=\frac{(63\cdot5-31-\frac{1}{2})^2}{63\cdot5}+\frac{(96-63\cdot5-\frac{1}{2})^2}{63\cdot5}=32\cdot26.$$

There is 1 degree of freedom. The tables for χ^2 show that this value is definitely significant, since it is greater than the value at the 0·01 probability level.

Example 3.

Out of 210 patients who contracted paralysis, 47 were treated in one way and 163 in another. In the first group seven were still paralysed after six months, and in the second group 48 remained paralysed. Do these figures indicate an association between treatment and recovery from the disease?

OBSERVED FREQUENCIES.

	Paralysed.	Unparalysed.	Total.
Group 1	7	40	47
Group 2	48	115	163
Total	55	155	210

If there were no association, we should expect the same proportion of recoveries in both groups. The totals of paralysed and unparalysed in the two groups together must be used to estimate the expected proportion, in addition to the number of patients in each group. We find for the expected figures,

EXPECTED FREQUENCIES.

	Paralysed.	Unparalysed.	Total.
Group 1	12·31	34·69	47
Group 2	42·69	120·31	163
Total	55·0	155·0	210

Then

$$\chi^2 = \frac{(7 - 12 \cdot 31 + \frac{1}{2})^2}{12 \cdot 31} + \frac{(40 - 34 \cdot 69 - \frac{1}{2})^2}{34 \cdot 69} + \frac{(48 - 42 \cdot 69 - \frac{1}{2})^2}{42 \cdot 69} + \frac{(115 - 120 \cdot 31 + \frac{1}{2})^2}{120 \cdot 31} = 3 \cdot 28.$$

Although there are four frequencies concerned, there is only one degree of freedom, because the data have been used to estimate the expected proportions in the classes. The rule for assessing the degrees of freedom in problems of this kind is to take the product of the number of rows minus one and the number of columns minus one. In this example there were two rows and two columns, the corresponding product is $(2 - 1)(2 - 1)$, so that there is one degree of freedom. There is no limit to the number of classes permitted.

The value 3·28 is not significant—so that no association between treatment and recovery was indicated by the figures.

If there had been three treatments and the patients divided into four classes according to their state of recovery, there would have been six degrees of freedom.

THE BINOMIAL AND POISSON DISTRIBUTIONS.

In the first paper of this series, the results were quoted of a dice throwing experiment carried out by Weldon. Twelve dice were used at a throw, and there were 4096 throws. The throws were classed according to the number of sixes which appeared in each. It was known before the experiment commenced that the probability of getting a six with any one of the dice was $\frac{1}{6}$. Remembering that the probability of an event is the proportion of times it occurs out of the total number of trials, when this number is very great, by applying the principles of permutations and combinations, it can readily be shown that the probabilities of getting no sixes, one six, two sixes, ... in a throw of twelve, are :

$$\left(\frac{5}{6}\right)^{12}, \; 12\left(\frac{5}{6}\right)^{11}\left(\frac{1}{6}\right), \; \frac{12 \times 11}{2}\left(\frac{5}{6}\right)^{10}\left(\frac{1}{6}\right)^2 \; \ldots .$$

Since there were 4096 throws, the expected frequencies are :

$$4096 \times \left(\frac{5}{6}\right)^{12}, \; 4096 \times 12 \times \left(\frac{5}{6}\right)^{11}\left(\frac{1}{6}\right), \; 4096 \times \frac{12 \times 11}{2}\left(\frac{5}{6}\right)^{10}\left(\frac{1}{6}\right)^2 \; \ldots .$$

The observed and expected frequencies could be compared by the χ^2 test to find whether the observations agree with expectations. There are thirteen classes, corresponding to 0, 1, 2, ... 12 sixes. Since the total frequency

4096, has been made to agree in the two distributions, there will be only twelve degrees of freedom. If the probability, $\frac{1}{6}$, had not been known beforehand, but had been estimated from the data by taking the total number of sixes divided by the total number of dice thrown (4096×12), the degrees of freedom would have been decreased by yet another one.

This is a particular example of the type of frequency distribution known as the Binomial distribution, which was found by Bernoulli.

The general result is that if the probability of an event is p, and the probability of its not occurring is q, then the probabilities of its occurring no times, once, twice, three times, ... in a set of n trials are given by the successive terms of the expansion $(q+p)^n$. If x is taken for the proportion of times the event occurs at a trial, the mean value of x is p, and the variance of x is $\frac{pq}{n}$. This distribution has important applications in biology. For example, it could be used to determine whether the number of plants surviving in different rows of a crop were distributed at random. If the frequency distribution of rows classed according to survival differed markedly from a binomial distribution, one might be led to infer the presence of some infectious disease among the plants, which was spreading along the rows. For this test to be valid, the initial number of plants must be the same in each row.

There is another important distribution, known as the Poisson distribution, which can be obtained as a special case of the Binomial distribution by making p tend to zero, and n tend to infinity, in such a way that np remains finite and equal to m. When these conditions are realized, the probabilities of the event happening 0, 1, 2, 3, 4, ... times at a trial are given by the terms of the series

$$e^{-m}\left(1,\ m,\ \frac{m^2}{2},\ \frac{m^3}{3\times 2},\ \frac{m^4}{4\times 3\times 2}\ \ldots\ .\right).$$

The average number of successes per trial is m, and the variance of the number of successes per trial is also m. When there is reason to believe that the conditions for a Poisson series should be satisfied, the randomness of an observed distribution can be tested by using χ^2 to compare the observed and expected frequencies. Student found that in counting cells with a hæmocytometer, the frequencies of occurrence of the squares containing different numbers of cells gave a Poisson series. This distribution is particularly applicable to studies of bacteria and fungi.

TECHNICAL NOTES

THE DETERMINATION OF THE AMOUNT OF NATURAL CROSS-POLLINATION IN CROP PLANTS.

It is well known that considerable variation in the amount of cross-pollination exists in most crops under different environmental conditions. It follows that a method for the determination of the amount of crossing, a basic requirement of plant improvement and seed multiplication work, will always be necessary to some extent. In a survey of methods of estimating crossing in different crops and in various countries, the writers have been impressed by two things: firstly, by the variations recorded within any one crop; for example, in sorghum, averages of 1-2% and 25% have been determined (13); and secondly, by a lack of uniformity of method. The method in general use may give results of doubtful accuracy, and it therefore seems feasible to assume that some of the great variations recorded can be attributed to faulty method.

The general method of estimating the amount of crossing is to sow alternate rows of two strains of similar maturity, one strain breeding true for a dominant character, the other for the allelomorphic recessive. The amount of crossing is then found by raising an F1 and/or an F2 from seed from the recessive parent, and obtaining the percentage of off or dominant types (1, 5, 6, 7, 8, 9, 10, 11, 12). In many cases this percentage has been given as the amount of cross-pollination. That this is incorrect has been pointed out by several workers (1, 9), who state that the amount of crossing must be at least twice as great, owing to there being an undetected and probably equal amount of crossing within the recessive parent. Woodworth (12) in fact makes the curious error of multiplying this percentage by four.

A doubling of this percentage cannot, however, be regarded as strictly accurate. An A (recessive) plant may be crossed by B (dominant) plants, by other A plants in the same row, or by A plants in other rows, and the proportion of A x B outcrosses may depend on the relative densities, round the plant A, of A and B plants. Pollen competition and the morphology and physiology of the flower may introduce further complications.

It is suggested that the objection to the use of alternate rows, or bulk plantings of alternate plants, can be overcome by using a single member of one strain in a block of the other. In practice, several widely separated plants of one strain would be sown in a field of the other. This method has been used to some extent (3, 4), at times not planned (2), but its advantages, which have never been stressed, would appear to warrant its further application. If A is crossed in such a case, it can only be by B; the circle of B plants overcomes

any vagaries in the direction of the wind (a point of importance, as shown by Takahashi and Hoshino (10) and by Patel and Patel (13), and there is an ample supply of B plants to provide pollen. Kearney (3) makes the point that for an absolute measurement of vicinism in crops having perfect flowers, such as cotton, the open flowers on the A plants must be restricted to one at a time.

With this method it can safely be assumed that the amount of crossing that would take place between two adjacent seed blocks of different varieties would be half that for the two strains themselves, which is of value when considering the degree of purity to be expected in the seed.

As it has been shown (3, 6) that the amount of crossing determined from the recessive parent alone may be definitely fallacious (in the test given by Pod'japol'skii (6) the amount of crossing as determined from the dominant strain was very considerably greater than that determined from the recessive), the test should also be made reciprocally in isolation.

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REFERENCES

(1) Griffee, F., and Hayes, H. K. Natural crossing in Oats. J. Amer. Soc. Agron. 17: 545-9, 1925.

(2) Karper, R. E., and Connor, A. B. Natural cross-pollination in Milo. J. Amer. Soc. Agron. 11: 257-9, 1919.

(3) Kearney, T. H. Self-fertilization and cross-fertilization in Pima cotton. U.S. Dept. Agr. Bull. 1134, 1-68, 1923.

(4) Kiesselbach, T. A. Corn Investigations. Nebr. Agr. Exp. Sta. Res. Bull. 20, 1922.

(5) Malinkovsky, M. Natural cross-pollination of commercial cotton varieties. Pl. Breeding Abs. (Camb.). 6:1:201, 1934.

(6) Pod'japol'skii, S. P. Cross-pollination in cotton. Pl. Breeding Abs. (Camb.). 6:1:203, 1934.

(7) Poggendorff, W. Flowering, pollination and natural crossing in rice. Agr. Gaz. N.S. Wales. 43: 898-904, 1932.

(8) Sielinger, J. B. Cross-pollination of milo in adjoining rows. J. Amer. Soc. Agron. 13: 280-282, 1921.

(9) Stanton, T. R., and Coffman, F. A. Natural crossing in oats at Akron, Colorado. J. Amer. Soc. Agron. 16: 646-659, 1924.

(10) Takahashi, N., and Hoshino, T. Natural crossing in *Setaria italica* (Beauv.). Pl. Breeding Abs. (Camb.). 4:4:995, 1934.

(11) Wilsie, C. P., and Takahashi, M. Natural crossing in the Pigeon pea. J. Agric. Res. 49: 923-27, 1934.

(12) Woodworth, C. M. The extent of natural cross-pollination in soy-beans. J. Amer. Soc. Agron. 14: 278-83, 1922.

(13) Bibliography on the breeding and genetics of the millets and sorghums. Imp. Bur. Pl. Genet. (Camb.)., 1932.

EUPLECTRUS AGARISTAE CRAWFORD, A PARASITE OF THE GRAPE VINE MOTH—*PHALAENOIDES GLYCINE* LEW.

Euplectrus agaristae Crawford (1), the larvæ of which are gregarious external parasites of the larvæ of the grape vine moth, *Phalaenoides glycine* Lew., a common pest of grape vines in New South Wales, belongs to the chalcidoid family *Eulophidae.*

The adult female, which measures 2.5 mm. in length, has the head and thorax black, the eyes being red. The dorsal surface of the abdomen is reddish testaceous with the margins dark brown. The legs and the base of the antennæ are slightly darker than the abdomen, the antennæ being darker distally.

This parasite was unusually abundant in the summer of 1935, and several generations were bred by the writer. Small potted grape vines were utilised in breeding cages, and the life history has been studied in detail.

The female wasp commonly selects grape vine moth larvæ of the fourth and fifth instar for oviposition, though sixth or last instar larvæ are sometimes successfully parasitised, and yield larger numbers of adults.

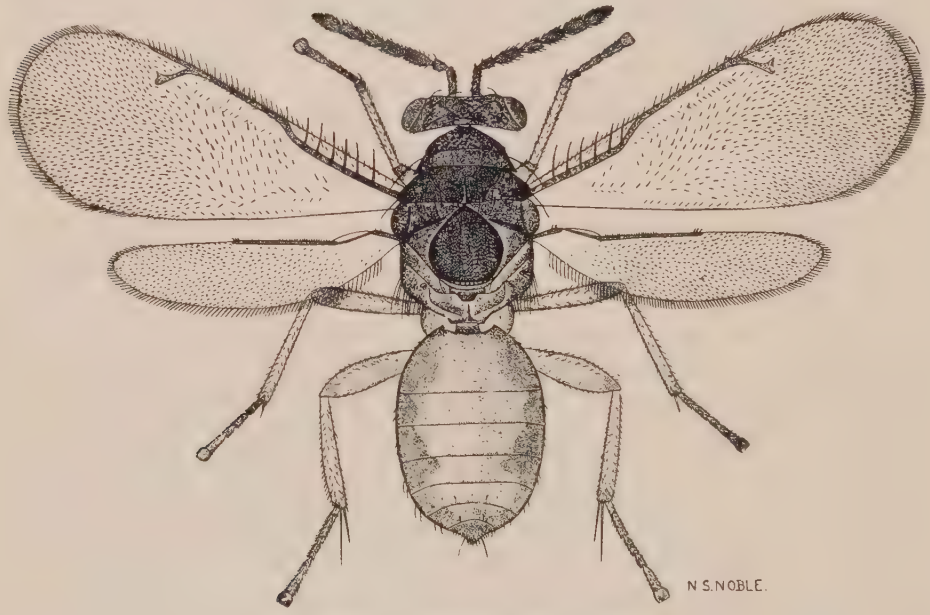
The female parasite on approaching a host larva, plays the tips of the antennæ over its integument and almost immediately crawls slowly onto its dorsal surface, sometimes even crawling up over its head. The larva immediately becomes agitated, deflects the head, twists and turns suddenly, and in its efforts to dislodge the parasite, sometimes releases its hold on the grape vine, and rolls over several times. The parasite is, however, seldom dislodged and is never injured. The larva soon tires and oviposition commences and is usually completed without interruption. The female wasp orientates itself at right angles to the length of the larva, and while the eggs are usually deposited on the dorsal surface of the anterior segments, they are sometimes laid as far back as the second last segment of the abdomen.

With the tip of the ovipositor, the female pierces the integument of the host larva, and a few moments later the egg appears, slides down the outside of the distal portion of the ovipositor and comes to rest on the integument of the larva over the site of the puncture. The ovipositor is withdrawn, the female moves on a little and repeats the process, always depositing the eggs in one small group, but slightly separated from one another. A number of eggs are laid in quick succession, as many as 31 being deposited in 10 minutes. The female then flies from the back of the larva and rests for a time before searching for further host larvæ.

The eggs are translucent and kidney shaped, having a smooth glistening surface, and they measure 0.244 mm. in length and 0.103 mm. in width; a

few moments after deposition, they are firmly fixed to the integument of the host and can only with difficulty be removed.

On hatching, the parasite larva breaks through one end of the egg and commences to feed externally on the host larva, and it remains in the one position until fully fed. At first the larvæ are slightly separated from one another, but with the progress of development they soon form one compact mass. The larvæ on hatching are more or less translucent but within 24 hours they change to a canary yellow color, which persists until shortly before they reach maturity, when they become grey in color.



Euplectrus agaristae Crawford. Adult female ×24.

The mature larva, which measures 3.24 mm. in length and 1.58 mm. in width, consists of a head and thirteen segments. The anterior nine segments form a large round body, the posterior five segments being extended to form a long narrow tail. The mandibles are amber in color, unidentate, somewhat triangular in outline and average 0.064 mm. in size.

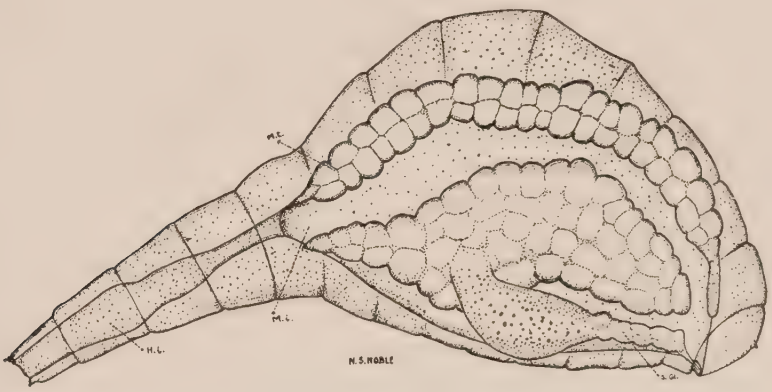
During the earlier stages of parasite development, the host larva continues to crawl about the grape vines and feeds in a normal manner, but as the parasite larvæ increase in size the host larva becomes sluggish and either just before or just after the parasite larvæ reach maturity, the host larva dies.

The parasite larvæ, on maturing, release their hold and pass down to the

underside of the host larva, and there each secretes from the anus an amber gelatinous fluid which dries to form coarse fibres. The elongate tail is extremely flexible, and by means of this the parasite larva attaches the dead host to the leaf surface beneath and eventually encloses itself in a crude cocoon in which it pupates.

The material used for the construction of the cocoon is secreted by the Malpighian tubes which have undergone amazing modification, and instead of the usual inconspicuous structures of typical Chalcid larvæ they consist of two very extensive branches which pass from the hind intestine forwards over the dorsal surface of the mid intestine almost to the head, there being also a smaller branch which lies between the other two.

Prior to pupation, the parasite larva extrudes the tip of the abdomen through the cocoon and voids a quantity of black liquid waste matter.



Euplectrus agaristae Crawford. Lateral view of mature larva ×30.

H.i. = hind intestine; M.i. = mid intestine; M.t. = Malpighian tube; S.Gl. = salivary gland.

The cocoons are so imperfectly constructed that the adults are able to force their way through to the exterior without the necessity of cutting through the fibres. All the adult wasps from any one mass of cocoons usually emerge within a few hours of one another.

Females far outnumber males; of 367 adults developed in the laboratory 320 or 87.19 per cent. were females and 47 or 12.81 per cent. were males. However, at least one male parasite developed on each host larva under observation.

Male adults always emerge first, and these sit on the cocoon masses and fertilise each female as it emerges. The total number of adult wasps developing from individual grape vine moth larvæ ranged from 2 to 60, the average

number being 17.82 from parasitised host larvæ collected in the field. From individual host larvæ parasitised in the laboratory, from 22 to 63 adult parasites developed, the average being 31.63.

In the laboratory breeding cages oviposition was sometimes excessive, many more eggs than could possibly develop normally, at times, being deposited on larvæ in cages in which apparently suitable hosts remained unparasitised. In one instance, 172 eggs were deposited on one maturing host larva. In cases of excessive oviposition the eggs all hatch and the larvæ reach a similar degree of development, and if sufficiently advanced at the time the food supply is exhausted, they all develop into miniature adults; but in other instances all the larvæ die of starvation.

In the laboratory in the summer of 1935 the incubation period ranged from 3 to 4 days, the average being 3.1 days. The larval feeding period ranged from 4 to 6 days, the average being 4.24 days. The prepupal period ranged from 2 to 3 days with an average of 2.26 days; and the pupal period ranged from 6 to 9 days with an average of 7.58 days. The total life cycle ranged from 16 to 20 days with an average of 17.73 days.

The average length of life of 271 individuals in the laboratory was 49.78 days with a minimum of 6 days and a maximum of 187 days. The longest period any male lived was 69 days, but a number of fertilised females which emerged in February survived until the following spring, a period slightly in excess of 6 months, and it is apparent that the parasite passes the winter in the adult stage.

The fact that the parasite larva feeds externally on a host larva which is itself feeding externally and is not paralysed prior to parasitisation, is unusual, while the construction of a cocoon by a Chalcid larva, and the secretion of the silk from the Malpighian tubes through the anus of the larva is also exceptional.

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(1) Crawford, J. C., Descriptions of new Hymenoptera No. 3 Proc. U.S. Nat. Mus., 41: 267-282, 1912.

THE OVERWINTERING OF THE LARVAE OF *TORTRIX POSTVITTANA* WALK IN APPLE ORCHARDS.

In certain apple-growing districts in Tasmania at the present time, the Light Brown Apple Moth, *Tortrix postvittana,* is responsible for a considerable amount of damage to fruit. The injury caused by the feeding of the larvae on apples consists of surface blemishes, and even in well-kept orchards the pest may be directly responsible for a loss of as much as 25 per cent. of the crop.

Tortrix postvittana is indigenous to Australia and has been introduced into New Zealand.

In the mainland States, the tortrix is nowadays seldom of serious economic importance. It has been generally assumed that its prevalence in Tasmania is associated with the early cessation of lead arsenate cover sprays, since in this State only one complete generation of Codling Moth has to be contended with.

During the course of an investigation concerned with the biology and control methods for this pest, certain facts have come to light that demonstrate the correctness of the association of the moth with the early cessation of lead arsenate sprays. However, the interpretation usually accepted, to the effect that damage is solely caused because fruit late in the season is unprotected from attack, has been found to be only in part correct.

Laboratory studies conducted last season disclosed the fact that although larvæ in the first three instars, if fed on foliage treated with lead arsenate, will succumb immediately, more mature larvæ avoid poisoned areas and, if only such are available, starve rather than feed.

Unlike those tortricids that are injurious to apples in Europe and America and which overwinter in the egg stage, *T. postvittana* is adapted for life on evergreen trees, and passes the winter in the larval stage. In feeding habits it is polyphagous, and previous investigators (1, 2). have suggested that it is unable to survive the winter in orchards, and that reinfestations take place each year from moths that have bred in shelter belts, gardens and in native vegetation adjoining orchards. If this were so, further explanation would be needed to account for the occurrence of this pest in Tasmanian orchards and not in those in neighbouring States, since effective control must depend rather on the presence of early cover sprays than on late ones, and the only significant factor not common to orcharding practices in Tasmania and the mainland States is concerned with late cover sprays.

During the past two seasons, evidence has been collected to show that the larvæ of *T. postvittana* can successfully overwinter in orchards. There are in Tasmania, two generations of the insect each year. Larvæ of the first generation occur from November to February, and the moths to which these give rise, from January to April. These moths oviposit on apple leaves, and

whilst doubtless those larvæ that hatch early in the season succumb to lead arsenate poisoning, many of those that hatch during March and April are able to feed with impunity until the leaves fall. Some of these will then feed on such weeds as may be available on the orchard floor, and it has been found that although no true hibernation takes place, larvæ that have reached the third instar can live for as long as two and a half months during the winter without feeding.

An examination during October, 1935, of flower-bud clusters on trees in orchards known to harbour this pest, resulted in the discovery of caterpillars on every tree investigated, the majority being confined to the lowermost clusters on each tree. Since in every instance the trees had been treated with red-oil some weeks previously, it was realised that the larvæ could not have overwintered on the trees, and it was assumed that they had climbed up from the orchard floor at the advent of a spell of warm weather.

In an endeavour to test the accuracy of this assumption several apple trees were banded with a sticky tree-banding material early in September, 1936. These bands were examined during the first fortnight in October, and in nearly every case trapped caterpillars were found, their numbers ranging from one to seven a tree.

It is thus apparent that although moths may enter and oviposit in orchards in any season, for infestations of any magnitude to develop, the population must be built up over a series of years. The reason for the occurrence of this insect as a pest in Tasmanian orchards and not in those in neighbouring States, is evidently due to the early cessation of cover sprays, the absence of any poison on the leaves late in the season permitting the survival of a proportion of second generation larvæ, many of which will overwinter successfully.

It will be appreciated that the establishment of this point is of considerable importance in connection with the development of control measures.

J. W. Evans.

Department of Agriculture,
Hobart, Tas.

(1) Dumbleton, L. J., The Apple leaf roller, *Tortrix postvittana*:
N.Z. Journ. Sci. and Tech. 14:(2), 83-92, 1932.

(2) Nicholls, H. M., The Light Brown Apple Moth:
Tas. Journ. Agric. 5:(2), 58-72, 1934.

THE USE OF MOISTURE EQUIVALENT AS AN INDEX OF TEXTURE FOR SOIL SURVEY PURPOSES.

Many attempts have been made to assess the texture of soils comparatively by means of a single value, the magnitude of which depends on the physical properties of the soil and affords a reliable measure of clay content. It was hoped that the single value known as Moisture Equivalent, being easy to determine, would enable a check to be made on apparent textures as observed in the field during a soil survey without the necessity of extensive mechanical analyses.

The correlation was seriously attempted on a large scale during the soil survey of part of the Murrumbidgee Irrigation Area. The scale of textures developed on earlier surveys and based on limiting clay percentages did not agree with the analyses of the Griffith-Leeton soils, and it was very desirable to have a quite reliable method of approximating the clay content. The amount present was often considerably higher than the apparent texture indicated. Moisture equivalents were determined on 520 soils and mechanical analyses made on roughly half of them.

It is recognised that the soils of one family only are to be compared and that within the family the soils must be grouped according to their character and position in the profile. In the present calculation it was assumed that every factor other than the clay such as organic matter, silt, ratio of coarse to fine sand, was exerting an equal influence on the final moisture equivalent figure within the three groups—surface soils, subsoils, and deep subsoils.

Scatter diagrams for the relation of moisture equivalent to clay for the three sets of figures were prepared and regression coefficients calculated. The equations of the three regression lines were:—

Surface soils	Clay = 1.88 M.E.	− 4
Subsoils	Clay = 1.57 M.E.	+ 8
Deep Subsoils	Clay = 1.10 M.E.	+ 15

Using the regression lines, the deviations of the estimated from actual clay values were read off, and in the table are shown the numbers of samples for which the deviation fell within 2%, 2-4% etc. limits.

Horizon	Approx. Depth inches	Clay Range %	pH Approx.	No. of samples in which estimated % deviated from actual by per cent. <2	2–4	4–6	6–8	8–10	> 10	Total No. of Samples
Surface	0–9	5–37	6.0–7.0	29	12	3	0	0	0	44
Subsoil	9–24	32–74	8.0–8.5	14	14	11	5	3	1	48
Deep Subsoil	> 24	36–74	> 9.0	13	17	10	4	1	4	49

It will be seen that the surface soils exhibit a good correlation, and the variations are probably largely a matter of organic matter differences. The subsoils and deep subsoils show fair correlation but are unsatisfactory, especially the latter. Both of them cover approximately the same clay range and are equally free of organic matter, low in soluble salts and reasonably similar in silt content. The regression lines are notably different under the circumstances. The groups are definitely different in degree of alkalinity, none of the subsoils exceeding pH 8.5 and none of the deep subsoils being lower than pH 8.9. The clays in the latter group are without doubt variable, but generally high, in replaceable sodium which would give an abnormal and high moisture equivalent. It is significant that the regression line for the subsoils with a mean clay content of 55% falls below all the plotted points for the deep subsoils which have a mean clay content of 52%.

The conclusions drawn from the attempts to use moisture equivalent as a direct measure of clay content on Murrumbidgee Irrigation Area soils are that the correlation for surface soils of approximately neutral reaction is good and can be used directly, that for the subsoils is fair and less reliable, and that for the deep subsoils unsatisfactory. Owing to subsoils and deep subsoils not agreeing as expected, due to differences in pH and degree of sodium saturation, there inevitably occur a number of soils between significant pH ranges which it is difficult to fit into either group.

J. K. Taylor.

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THE SPREAD OF TAKE-ALL THROUGH THE SOIL.

That the take-all disease of wheat tends to develop in circular patches is a familiar observation. This formation is generally believed to be due to the spreading of the causal fungus through the soil, although till recently the manner of this spreading had not been clearly demonstrated. The question arises: can the fungus itself grow through bare soil or is the presence of the living roots of a susceptible plant necessary? The question has been partly answered by Padwick (1) who has shown that the presence of living susceptible roots as compared with their absence does facilitate the spread of the take-all fungus, *Ophiobolus graminis*, through soil.

The purpose of this note is to describe briefly the results of an experiment which help to confirm Padwick's conclusions. The experiment, which was instituted before Padwick's results became available was, of course, carried out in rather a different manner. The experiment was conducted in the open during the 1935 growing season and lasted over the whole growth period of the wheat plants.

A series of small beds was set out at the Waite Institute on a red loam fallowed since the previous winter. In some of the experimental plots the surface soil to a depth of ten inches was removed and the hole filled with Torrens river sand. In one of these plots the sand, prior to being placed in position, was heated in an autoclave at 2 atmospheres for 1 hour, thus effecting a temporary and probably partial sterilization. The Waite soil removed from another plot was also treated in the same way, and then returned to its original position. The plots, with one exception, were rectangular, 2ft. or 4ft. wide and 6ft. long; the other plot was circular with a diameter of 6ft. In the middle and across the width of the rectangular plots, and in the centre of the circular plot inoculum consisting of a pure culture of *Ophiobolus graminis* grown on a barley hull medium was introduced into shallow trenches. This inoculum was then covered lightly, and immediately above Nabawa wheat disinfected with N/100 $AgNO_3$ (2) was planted.

In each rectangular plot, two rows of fairly thickly seeded wheat were planted immediately over this inoculum. At distances 2in., 4in. and 8in. respectively—according to the plot—other rows of disinfected wheat were planted, the distance between seeds within the rows being the same as that between the rows. In the circular plot, the wheat was planted in circular rows 12in. from the central batch of inoculated seedlings and spaced at least 12in. from each other. The wheat above the inoculum was planted separately and two weeks prior to that of the rest of the plot, and care was taken to avoid any mechanical spreading of the inoculum when planting the remainder of the plot. The results were based on an examination after the plants had reached maturity. In each row, discarding border plants, there were at least six plants available for examination. These were removed serially, one from each row, starting with the plant next to that which was inoculated, and these six sets of plants, later referred to as columns, were taken to the laboratory for detailed examination. In this examination severely diseased plants were easily distinguished, but as one proceeded outwards from the inoculated zone a decision on this point became more difficult. Finally, information concerning the spread of infection was gained in the following way. All columns in all the plots were examined macroscopically to obtain approximate information on the spread of the disease. Plants from two or more of the columns in which the disease had spread furthest were selected for a more detailed examination under the binocular, and in each

column two plants were sought particularly, viz., the innermost healthy plant and the outermost diseased plant. The roots of these plants, together with those of one or two intermediary plants whose infection status was doubtful, were then used—each separately—to inoculate sterile sand in which wheat seedlings were grown. After three to four weeks the seedlings were washed out and examined for evidence of take-all lesions. Where these occurred, steps were taken to confirm this evidence by isolating the fungus from the diseased roots, a procedure which is comparatively simple in seedlings of this age. All the columns chosen for detailed study were followed out to the point where the evidence yielded by a test of the character indicated, was completely negative.

RESULTS.

The plants in the inoculated rows, with one or two exceptions, were severely affected and died as seedlings. The infection of their roots by *Ophiobolus* was demonstrated. The accompanying table gives particulars of the furthest observed spread of take-all under the conditions set out.

Soil.	*Treatment.*	*Planting distance* (inches).	*Max. distance of observed* (inches).
Torrens sand	Nil	2	20
"	"	4	12
"	"	8	8
"	"	12	0
"	Heated	4	20
W.I. loam	Nil	4	16
"	Heated	4	16

From these results it is clear that the presence of living wheat roots has an influence on the spread of take-all through soil.

D. B. Adam and
T. T. Colquhoun.

Waite Agricultural Research Institute,
University of Adelaide, S.A.

(1) Padwick, G. W., Can. Journ. Res. 12: 575, 1935.
(2) Mead, H. W., Scient. Agric. 13: 304, 1933.

NON-REPLICATED FACTORIAL EXPERIMENTS.

The design of non-replicated factorial experiments, an example of which was described by E. A. Cornish in this Journal (Vol. 2, No. 2, pp. 79-82), is something more than a convenient statistical development. From tests current here, sown to Cornish's design, it would appear that the method constitutes a major improvement in agronomical experimental work. The importance of the opportunity so presented, to study the reactions of several varieties under different cultural conditions in a small compact experiment, cannot be over estimated. Not only have the results from such an experiment a wider application from, say, a manurial standpoint, but they also lead to a much better appreciation of

the essential differences between even well known varieties. And about the most widely grown varieties of the cereals alone, much has still to be learnt.

The Werribee experiments have not yet been harvested, and it is but the purpose of this note to express the writer's appreciation of the method and to further draw the attention of agronomists to it in good time for inclusion in next year's programme.

A. J. Vasey.

State Research Farm,
Werribee, Vic.

The Australian Institute of Agricultural Science

FIRST GENERAL MEETING.

The attention of members is again directed to this, the most important fixture of the Institute since its establishment in January of last year:

THE FIRST GENERAL MEETING OF THE INSTITUTE
TO BE HELD AT
SCIENCE HOUSE, GLOUCESTER & ESSEX STREETS, SYDNEY,
ON
JANUARY 6th & 7th, 1937.

The programme for the sessions has been arranged as follows:

6th January—	10 a.m.	Federal Council Meeting.
,,	2 p.m.	First General Meeting. Business Session.
,,	8 p.m.	First General Meeting. Presidential Address.
7th January—	10 a.m.	First General Meeting. Business Session cont'd.

It is hoped that as many members as possible will wear evening dress for the evening session on 6th January.

A. J. Vasey,
Honorary Secretary.

CANBERRA (F.C.T.) BRANCH.

On May 27, Professor S. M. Wadham addressed members of the Branch on "The Work of the Wheat Commission." He dealt in his inimitable, whimsical manner with some of the "behind the scenes" evidence, and showed in a crisp telling way how such real work was involved in sifting evidence and producing such a monumental report.

On August 25th, Dr. J. A. Gilruth spoke to members on "Agriculture in Relation to Animal Health." His examples from long personal experience of diseases of stock filled his hearers with admiration for the sound treatment given by veterinary officers to ailing animals, based on keen observation and wise judgment, before the scientific knowledge of trace element deficiencies had become known in such troubles as wasting diseases.

NEW SOUTH WALES BRANCH.

The eighth meeting of the Branch was held at Science House on October 16, the President, Dr. R. J. Noble, occupying the chair. The main business was a detailed consideration of the Constitution of the Institute and the formulation of notices of motion re alteration thereof for submission to the Hon. Secretary for consideration at the First General Meeting of the Institute to be held in January.

The ninth meeting of the Branch was held on November 13. There was an attendance of 15 members, the President, Dr. Noble, occupying the chair. The main business consisted of three short addresses:

"Recent Progress in Some Aspects of Dairy Chemistry," by Mr. A. V. Robinson. It was stated that considerable attention had been devoted to the composition of milk, and the effect on it of such factors as the age, breed, diet, and period of lactation of the cow. The use of fats and oils in the diet had been shown to give temporary depression of butterfat percentages in some cases, and elevation in others. The work on butterfat had been particularly concerned with the separation and identification of the fatty acids, the effect of feeding on the composition of the fat, and the oxidative and hydrolytic changes responsible for the development of taints. The type of food caused considerable alterations in the characteristics of the fat, especially in the iodine value, and also in the hardness of the fat, and its colour. These characteristics were reflected in the butter. The investigations of the oxidative and hydrolytic changes in the fat which were the cause of "tallowy," "oily" and "rancid' flavours, had demonstrated the necessity for the prevention of contamination by traces of heavy metals, such as copper and iron during manufacture. Some interesting recent work had shown that substances which have a protective effect against the development of oxidised flavours, can be transmitted by the cow to the milk. Mr. Robinson also discussed the recent work on problems of homogeneity in proteins, on properties of lactose, and the use of zeolites for removal of calcium and phosphorus from milk by base exchange methods. The progress in the field of physical chemistry was also outlined.

"Some Recent Developments in Non-arsenical Insecticides," by Mr. W. L. Morgan. It was stated that for some insect pests of fruit and vegetables, effective control with arsenicals could only be obtained at the risk of contaminating the produce with excessive arsenical residues, and the removal of these residues by washing or wiping was often difficult or impracticable. At present the focus of attention was organic chemicals, and the results to date were quite promising. Of the wide range of synthetic organic compounds tested, a few had shown promise, especially thiodiphenylamine and certain aliphatic thiocyanates. The former at 1 in 1,000,000 was very effective against the mosquito larvæ and was considered to be more toxic than rotenone, the chief ingredient of derris and cube, and which is itself recognised as the most powerful stomach poison and contact insecticide. The advances made with the plant materials nicotine, pyrethrum, cube and derris were of very definite value in insect control. The discovery that nicotine in nicotine tannate and nicotine absorbed in bentonite was retained on foliage for as long as 21 days in quantities toxic to young codling moth larvæ was important, as it opened up possibilities for the use of nicotine as a stomach poison for mandibulate insects. It was pointed out that the chief constituent of derris and cube is rotenone, but derris containing only a trace of rotenone had given effective control of insects. Experiments extending over the last three years in New South Wales had shown derris and cube dusts to be effective non-arsenical substitutes for lead arsenate for control of cabbage moth in cabbages and cauliflowers.

"Some Bacteriological Defects in Eggs," by Mr. W. S. Sutton. An article dealing with the substance of this address and additional features will be contributed by Mr. Sutton in the March, 1937, issue of this Journal.

VICTORIAN BRANCH.

On the 31st July, Miss M. J. Griffiths, B.Sc., a graduate of Reading University, addressed a combined meeting of the M.U.Ag.Sc. and the Victorian Branch of the A.I.A.S. on the "Production of Clean Milk in England." The system of dairying and agricultural education in relation to clean milk production was outlined briefly, and a description of the well organised scheme of publicity and extension work to increase the consumption of milk was given.

The speaker on 13th August was Mr. Ratcliffe, of the C.S.I.R., who spoke on "Soil Erosion in Eastern Australia." The type of country affected and the chief erosion problems were clearly described.

Students' night was held on 11th September, when Mr. L. C. Holmes described "The Dairy Industry in the Western Strzeleckis," and Mr. R. J. Swaby dealt with "Some Aspects of the Problem of Maintenance of Soil Fertility."

On 9th October, Mr. G. W. Leeper gave an address on "The Nature and Origin of Some Western District Soils." The soils derived from the "Newer Basalt" cover about 10,000 square miles of south-western Victoria. Little work has yet been published about these soils, which vary very much in spite of the uniformity of the basalt. This address dealt with some of the results of a survey of two adjoining pastoral properties in this district. The area under survey covers 12,000 acres: it includes a volcanic cone (Mt. Gellibrand) and is marked by innumerable ridges of basalt known as "stony rises." The volcano in its explosive phase brought up large amounts of quartz sand with the tuff, and this sand has affected the nature of some of the soils, especially to the south-east of the mountain (indicating that the prevailing wind was from the north-west at the time of the eruption). In addition to a general moderate leaching, there has been some erosion of the clay fraction from the stony rises followed by its deposition on the gentler slopes and in the numerous swamps, and all these factors have played their part in determining the nature of the present soils. The development of "crabholes" in certain of the heaviest clay swamps is a particularly interesting feature of the survey. The minerals present in the fine-sand fractions of the various soil types were also studied, and this gave valuable information about the history and relative maturity of the types. (This work was done in collaboration with Professor Wadham and Miss A. Nicholls.)

On 6th November, Dr. Ivan Maxwell gave an interesting description of his recent trip through the Continent, America and Japan. Of special interest to agriculturists was the account of rural life in Russia, and his comments on the system of collectivisation of farms along the western boundary of that country.

SOUTH AUSTRALIAN BRANCH.

The third general meeting for the current year was held on 24th September, with an attendance of 23 members. The evening was devoted to a consideration of quality in wheat.

Mr. A. J. Farquhar, of the Department of Chemistry, Adelaide, spoke on "The Nature of Quality and the Methods for its Determination." The speaker stated that protein determination was of much value, but that as the protein content rose above 9 per cent., its importance as an indicator of baking quality tended to become reduced. The

main reasons for low flour strength were to be found in an inferior content or quality of protein, unfavourable diastatic or proteolytic enzyme action, hydrogen ion concentration, etc., which influence yeast activity. The various tests available for the determination of baking quality were reviewed in detail, with particular reference to the information to be gained by the use of the recently developed Farinograph and Fermentograph.

Mr. E. J. Breakwell, Plant Breeder of Roseworthy Agricultural College, dealt with "Quality as a Factor in Wheat Breeding." Mr. Breakwell said that breeding for high quality in wheat had only been seriously adopted in Australia during the last four years. Previously quality had been regarded as being so strongly linked with low yield as to be inescapable from it. The Pelshenke test was of definite value to the plant breeder, particularly in the case of material grown in the same environment, the speaker continued. The inheritance of quality as shown by distribution curves within F_2 plants was strikingly demonstrated by this test. The breeding programme at Roseworthy College included the constant testing of crossbred drill strips for quality, and types showing a high test were retained for the investigation of other attributes necessary in a commercial variety.

WESTERN AUSTRALIAN BRANCH.

Since the inauguration of the Branch in October, 1935, the standing of this body has been consolidated and the wants of members catered for both by professional and social meetings, and by collective action lending moral support to those working toward the improvement of the lot of agricultural scientists in the service of the community. The membership has beeen strengthened and now stands at 39 corporate members and 11 student members. The Branch strongly supports the movement to maintain and improve the standard of qualifications for entry.

General meetings are held bi-monthly. The business part of the programme is followed by an address of professional interest, and the breadth and keenness of the ensuing discussions have exemplified the interest of members. This year, local talent has been supplemented by visits of members from other States in the persons of Mr. G. de Vahl Davis and Professor J. A. Prescott, whose addresses have been of considerable interest. The following topics have been discussed since our last report:—Mr. G. de Vahl Davis, "Fertiliser Research Abroad"; Mr. A. B. Adams, "The Export Lamb Industry"; Mr. B. L. Southern, "Copper Bunticides"; Professor J. A. Prescott, "The Chemist in Agriculture"; Dr. E. J. Underwood, "The Relation of nutrition to the growth and wool yield of Merino Sheep in the Western Australian Wheat Belt."

QUEENSLAND BRANCH.

The eighth meeting of the Branch was held in Brisbane on the 2nd of October, and there was a large attendance of members and visitors, the latter including Messrs. A. B. Cashmore (F.C.T. Branch) and R. Roe (W.A. Branch). The President (Mr. R. Veitch) occupied the chair. Professor E. J. Goddard, Dr. D. A. Herbert and Mr. J. E. C. Aberdeen were elected to corporate membership of the Branch and five nominations for membership were received. An address on "The Hawaiian Pineapple Industry," illustrated by lantern slides, was given by Mr. H. K. Lewcock. After outlining the history and present organisation of the industry in Hawaii, Mr. Lewcock gave an account of the cultural methods employed in this large-scale agricultural enterprise, and indicated how increased efficiency in planatation practices is being achieved through application of the results of investigational work being carried out at the Pineapple Experiment Station. It was stated that this Experiment Station is financed wholly by the pinapple industry at a cost of more than 200,000 dollars annually. Several members and visitors contributed to the discussion which followed, including Dr. F. H. S. Roberts and Messrs. A. F. Bell, W. G. Wells and E. H. Gurney.

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Book Reviews

The Chemistry of Milk, by W. L. Davies, D.Sc., Ph.D., F.I.C.
(Pp. xii. + 522, with 26 figures and 126 tables. London: Chapman and Hall, Ltd., 1936. Price, 25/-.)

"The Chemistry of Milk," by W. L. Davies, is one of a series of monographs on applied chemistry, edited by E. H. Tripp and published by Chapman and Hall. Dr. W. L. Davies is Research Dairy Chemist and Analyst at the National Institute for Research in Dairying, Reading, England.

The book is a compendium of some 500 pages of information concerning the composition, constituents, physical chemistry and nutritive value of milk, together with a part devoted to the chemistry of milk proceessing. His references are given at the end of each chapter, are well arranged and comprehensive; and it is interesting to see occasional references to work done in Australia, particularly to that of H. B. Taylor. The subject matter of the book is arranged in five parts under the headings "The Composition of Milk," "The Constituents of Milk," "The Physical Chemistry of Milk," "The Chemistry of Milk Processing," and "The Nutritive Value of Milk."

In an introductory chapter, the author draws attention to the conveyance from the mother to the offspring of immunological factors in the colostrum and suggests that the high proline content of globulin is instrumental in the formation of haemoglobin for the rapidly increasing blood volume of the newly born animal. Later on he draws attention in this connection to the importance of the iron content of colostrum being seventeen times that of normal milk. With regard to milk fat, he has no doubt that the lower fatty acids are suited to the requirements of the modified catabolic capacity of the newly born animal. A consideration of certain factors concerned in butter deterioration is contained in a chapter dealing with milk-fat or butter-fat. In discussing the autoxidation of butter-fat, the author draws attention to the fat-water droplet interface as undoubtedly the site of chemical action involved in the deterioration of the fats since at this interface are located the curd, water, lecithin, oxygen, and the concentration effects of the spherical surfaces on these reactants. The mechanism of trimethylamine liberation in butter is explained by the author as the action of organic peroxides on the choline residue of

lecithin, causing a mild Fenton type of oxidation which is strongly catalysed by traces of copper, iron, and other metal salts. He states that Callaghan's idea of "fishiness" in 1904 as being due to an Oidium is sound in principle, and that overworking or renovating butter brings more lecithin from the fat and aids the development of "fishiness."

In regard to enzymes in milk, the general conclusion seems to be that they are present as rudimentary, non-functioning constituents, and that it is only in abnormal secretion, such as in colostrum, end-of-lactation milk, and milk from diseased udders, that enzymes appear to be functional. A table of enzymes of milk and their substrates, the pH range, and thermal inactivation points, is given.

In addition to chapters on the nutritive value of the constituents of milk, consideration is paid to the nutritive value of milk as a whole in the final chapter. Instances are given of the marked influence of milk in the diet of the child.

The book is a welcome addition to the series, and should be on the shelves of every dairy chemist and bacteriologist.

J. K. Murray.

Farm Soils—Their Management and Fertilisation, by E. L. Worthen, M.S.

(Second Edition. Pp. xiii. + 468, with 220 figures and 46 tables. London: Chapman and Hall, Ltd., New York: John Wiley and Sons, Inc. 1935. English price, 13/6.)

This, the second edition of Professor Worthen's "Farm Soils," gives a succinct yet comprehensive survey of the principles and practice of soil management as applied to field, pasture, garden and fruit soils.

The results of recent progress in various branches of soil science are illustrated in the chapters dealing with drainage, tillage, manuring, liming, fertilising of the land, and with the management of field crops, pastures and orchards, and selected references are given with each of the main topics discussed.

The organisation of the subject matter on the basis of practical field operations has been followed throughout, and useful exercises on the application of the subject matter to community studies, together with practical problems for the reader, are given at the end of each chapter.

Those portions of the book dealing with the control of the water supply of the soil, liming, utilisation of legumes and management of pastures, reflect the progress made in recent years in soil science and pasture management.

Professor Worthen's book presents a balanced survey of the problems of soil management. The wealth of material drawn from United States Experiment Stations to illustrate the problems of soil fertilisation and management makes it a particularly useful text book for workers on the North American continent.

A. E. V. Richardson

Current Notes and News

AGRICULTURAL SCIENCES CLUB, SOUTH AUSTRALIA.

Meetings of the Club were held in August and October, the September date being devoted to a meeting of the South Australian Branch of the A.I.A.S.

At the August meeting, short papers and exhibits were given; an outline of these appears hereunder.

Mr. A. B. Beck presented a paper entitled "The Chemistry of Soil Colour." Twenty-four soils representing a range of colour types established by the Soils Division of the C.S.I.R. were examined for their content of humus and of free iron oxide, in an attempt to correlate the chemical composition with the soil colour. This work has formed the chemical part of a series of investigations which deal with the nature of soil colour and are being carried out by the Soils Division.

Mr. L. J. Dumbleton spoke on "The Entomological Work of the Cawthron Institute, Nelson, N.Z." Entomological work in New Zealand had concerned itself chiefly with problems of biological control. Fifteen out of sixty parasites that had been introduced for various purposes had become established. Notable examples were the wasp *Aphelinus mali* against woolly aphis, a lady-bird against cottony cushion scale, a wasp against golden oak scale, and the control of the eucalyptus weevil by means of an egg parasite. Attention had also been given to the problem of the European earwig and codlin moth, as well as to the native grass grubs, but so far with little success. The question of the possible biological control of certain noxious weeds such as gorse, blackberry, ragwort and sheep's burr was also dealt with.

Mr. A. W. Peirce gave a paper on "The Effect of Excess Alkali in the Diet of Sheep." He discussed feeding experiments that had been conducted over the preceding two years. Three groups of sheep were used, all receiving an adequate diet. Two groups received excess Ca and Mg in their ration, one group of which received in addition 5 c.c. of cod liver oil per day. The third group was the control. Body weight trend and wool production showed that the high-alkali groups were not adversely affected in the experiment. Vitamin D was known to assist in correcting an adverse Ca/P ratio, the speaker stated. The full paper will be published shortly.

Mr. R. J. Best presented an exhibit, illustrated by means of graphs, which dealt with the activity of tobacco mosaic virus in relation to H-ion concentration.

The October meeting was devoted to a discussion of "The Potential Population-Carrying Capacity of South Australia," estimated from the agricultural point of view, according to present knowledge. The discussion was undertaken with the objective of determining, at first in a preliminary way, the extent to which agricultural production could be increased in the light of the known limitations imposed by soil and climate, and as a result of improved agricultural methods. It was felt that in view of the diverse and unqualified estimates that had been made in the past regarding Australia's capacity for absorbing an increased population, the Club would perform a service in arranging for a discussion based on the knowledge that has been accumulated in recent years regarding this particular State's agricultural possibilities. It was hoped, furthermore, that in the event of the discussion proving fruitful, the question might be taken up by the Institute of Agricultural Science, with a view to the ultimate assessment of Australian agricultural resources as a whole.

The discussion was opened by Professor A. E. V. Richardson, who dealt with the general question of agricultural development in South Australia, with particular reference to the wheat and pastoral industries. Mr. H. C. Trumble next spoke in terms of the capacity for improved pasture production in those areas of the State receiving more than 15 inches of mean annual rainfall. Mr. A. G. Strickland discussed the future possibilities of the State in regard to the production of fruit and wine; and Professor J. A. Prescott dealt with the irrigated and irrigable areas. Finally, Mr. L. J. Cook, who has had extensive experience of pasture management in the Kybybolite district, spoke on the possibilities for development in the south-east of the State.

The above papers were followed by a general discussion, in which such questions as the standard of living and the ratio of the number of holdings to the total urban and rural population were brought forward. The general purpose of this particular discussion, however, was to assess the capacity of the land entirely in terms of primary production, and questions regarding the secondary industries, the standard of living and the marketing problems associated with increased primary production were excluded.

Arrangements were made for a further development of this topic at a general meeting of the S.A. Branch of the Australian Institute of Agricultural Science in November. Professor A. E. V. Richardson consented to review the material submitted at the October meeting of the Agricultural Sciences Club; Mr. J. A. La Nauze, Lecturer in Economics at the University of Adelaide, and Mr. G. J. Seaman, of the Auditor-General's Department, South Australia, were also invited to contribute papers to the November meeting.

RANSON MORTLOCK BEQUEST.

A gift of £25,000 for the purpose of research into the problems of soil erosion has been made to the University of Adelaide by the family of the late Mr. Frederick Ranson Mortlock. The gift, which will be known as the "Ranson Mortlock Trust," will be devoted to research work in connection with soil erosion and the regeneration of pastures on pastoral lands. It provides for a suitable building to be erected at the Waite Agricultural Research Institute to be named the Ranson Mortlock Building. Plans for this building are in the course of preparation.

Personal Notes

CANBERRA, F.C.T.

Drs. I. M. Mackerras and J. H. Riches returned to Canberra on October 21st after a nine weeks' tour of western New South Wales, South Australia and Victoria, surveying the blowfly problem there.

Mr. L. Corkill, from the Plant Research Station, Palmerston North, New Zealand, joined the Plant Introduction Section, C.S.I.R., in August. He is stationed at Canberra studying introduced grasses.

Mr. J. F. Miles, of the Plant Introduction Section, C.S.I.R., was transferred in August from Canberra to Rockhampton, Queensland, to establish and take charge of a new plant introduction station for Middle Queensland at Fitzroy Vale, near Rockhampton.

Mr. R. Roe was appointed to the Weeds Section, C.S.I.R., at Canberra in July. He was transferred in late September to the Queensland Agricultural High School and College, Laws, where he will work on nutgrass and galvanised burr problems.

Mr. R. W. Prunster took up duty with the Weeds Section ,C.S.I.R., in the beginning of November. He comes from the Department of Agriculture of Western Australia. In December, he will be transferred to the Murrumbidgee Irrigation Area, where he will work on the problem of bulrush control.

Dr. C. Barnard has been engaged on a survey of die-back in apples and pears in Victoria and South Australia.

NEW SOUTH WALES.

Prof. Dr. Walter Mohr, of Kiel, visited the State Department in October.

Mr. J. N. Barrett, of "Yera," Edgeroi, returned last month from a visit to the United States.

Mr. R. H. Anderson was appointed Botanist and Curator of the National Herbarium, N.S.W. Dept. of Agriculture, in September—succeeding Mr. Edwin Cheel, retired.

Mr. S. Smith-White has been appointed to a botanical post in the Technological Museum, Sydney, dating from February 1st, 1937. At present he is the assistant plant breeder at New England Experiment Farm, Glen Innes.

Mr. C. E. Ahrens is severing his connection with the N.S.W. Dept of Agriculture, to take over the position of Principal of the Navuso Agricultural College in Fiji. He will sail in January for Suva.

VICTORIA.

Professor S. M. Wadham was recently elected to the Council of the Royal Agricultural Society of Victoria.

Recent appointments to the research staff of the Department of Agriculture include Miss M. Cowan (Asst. Seed Analyst) and Mr. J. P. Ryland (Asst. Plant Pathologist).

On his return from abroad, Mr. T. S. Bellair accepted a new position as Assistant Director of Food Laboratories Pty. Ltd.

Mr. K. M. Ward resigned recently to take up the position of Horticultural Research Officer with the Queensland Department of Agriculture. He will be stationed at Stanthorp.

Messrs. J. R. McMillan, A. McTaggert and Dr. B. T. Dickson of the C.S.I.R. and Mr. N. R. Foy, Seed Analyst of Palmerston North, New Zealand, inspected the Pasture Research Field and the Plant Research Laboratory, Burnley and the State Research Farm, Werribee, when passing through Melbourne from the conference of Seed Testers and Agrostologists held in Adelaide recently.

SOUTH AUSTRALIA.

Professor J. A. Prescott visited Western Australia for one week in September, and spent most of this time in association with those officers of the Forests Department interested in soil surveys and in the culture of pine plantations.

The soil survey party of the Soils Division, C.S.I.R., consisting of Messrs. J. K. Taylor, P. D. Hooper, J. G. Baldwin and G. D. Hubble have commenced work at Mildura in connection with the final major survey in the irrigation areas. Mr. Taylor also recently visited the Murrumbidgee irrigation areas, in order to carry out the final correlation of the soil types which have been established during the last three years.

Mr. E. S. Edmiston, Lecturer in Industrial Chemistry, of the University of Queensland, is spending the long vacation at the Waite Institute, with particular regard to soil investigations.

Mr. L. G. Vallance, of the Queensland Department of Agriculture, is visiting the Waite Institute for a period of three months in connection with problems of pineapple chlorosis. He is specially interested in the availability of iron and manganese in the soil.

Dr. J. Davidson and Mr. H. G. Andrewartha recently visited the northern pastoral areas in connection with the investigations of the grasshopper problem. For this purpose a motor utility truck has been provided by the C.S.I.R.

Mr. A. B. Beck, M.Sc., who was a voluntary worker in agricultural chemistry at the Waite Institute from February to October, 1936, has received an appointment in the Department of Agriculture, Western Australia.

Recent visitors to the Waite Institute have been numerous. These include Her Excellency Lady Gowrie, Sir Geoffrey Whiskard, High Commissioner in Australia for the United Kingdom, 24 members of the New Zealand farmers' delegation, 126 delegates to the Agricultural Bureaux Conference in Adelaide, the Agricultural Instructors of the S.A. Department of Agriculture, members of the Conference of Australasian Seeds Merchants, members of the Australian Conference of Agrostologists and a large number of pastoralists from the Eastern States.

QUEENSLAND AND TASMANIA.

Mr. B. E. V. Parham, of the Fijian Dept. of Agriculture, recently visited Queensland to investigate tropical fruit production methods in this State.

Mr. E. R. Hudson, Superintendent of Extension Services in the Tasmanian Department of Agriculture, left Tasmania on 12th October to take up the position of Director of Canterbury Agricultural College, Lincoln, New Zealand. On the 8th, a number of members of the Institute assembled to bid him farewell. The president of the Tas. Branch (Mr. Bevin), when making the presentation of a figured Tasmanian blackwood walking stick suitably engraved, referred to the prominent part Mr. Hudson had played in forming the Tasmanian branch.

Mr. P. H. Thomas, Chief Horticulturist in the Tasmanian Department of Agriculture, returned on 2nd November from a visit to the principal fruit-growing districts in the West Pacific States and the provinces. He was very impressed with the efficiency of the workers in the industry, and the high standards of quality, packing and presentation.